CLAIMS

1. A high-density electrode, obtained by impregnating a high-density electrode which comprises an electrode active substance and carbon fiber having a fiber filament diameter of 1 to 1,000 nm and has a porosity of 25% or less, with a solid polymer electrolyte.

2. The high-density electrode as claimed in claim 1, wherein the carbon fiber is graphite carbon fiber which has undergone thermal treatment at 2,000°C or higher.

3. The high-density electrode as claimed in claim 1 or 2, wherein the carbon fiber is graphite carbon fiber having a surface onto which an oxygen-containing functional group has been introduced through oxidation treatment.

4. The high-density electrode as claimed in any one of claims 1 to 3, wherein the carbon fiber is graphite carbon fiber containing boron in an amount of 0.1 to 100,000 ppm.

5. The high-density electrode as claimed in any one of claims 1 to 4, wherein the amount of the carbon fiber is 0.05 to 20 mass%.

6. The high-density electrode as claimed in any one of claims 1 to 5, wherein the carbon fiber has an average aspect ratio of 5 to 50,000.

7. The high-density electrode as claimed in any one of claims 2 to 4, wherein the graphite carbon fiber has, at a (002) plane, an average interlayer distance (d_{002}) of 0.344 nm

or less as measured by means of X-ray diffractometry.

8. The high-density electrode as claimed in any one of claims 1 to 7, wherein the carbon fiber has, in its interior, a hollow structure.

9. The high-density electrode as claimed in any one of claims 1 to 8, wherein the carbon fiber contains branched carbon fiber.

10. The high-density electrode as claimed in any one of claims 1 to 9, wherein the electrode active substance is a carbon material.

11. The high-density electrode as claimed in claim 10, wherein the carbon material contains Si.

12. The high-density electrode as claimed in claim 10 or 11, wherein the carbon material is a non-graphite carbon material, and the bulk density of the electrode is 1.5 g/cm^3 or more.

13. The high-density electrode as claimed in any one of claims 10 to 12, wherein, before being formed into an electrode, the carbon material serving as the electrode active substance is in the form of carbonaceous particles satisfying the following requirements:
(1) average roundness as measured by use of a flow particle image analyzer is 0.70 to 0.99; and
(2) average particle size as measured by means of laser diffractometry is 1 to 50 μm.

14. The high-density electrode as claimed in claim 10, 11 or

13, wherein the carbon material contains a graphite material in an amount of 50 mass% or more, and the bulk density of the electrode is 1.7 g/cm^3 or more.

15. The high-density electrode as claimed in claim 14, wherein the graphite material contains boron.

16. The high-density electrode as claimed in claim 14 or 15, wherein, before being formed into an electrode, the carbon material serving as the electrode active substance is in the form of carbon particles containing, in an amount of 50 mass% or more, graphite particles satisfying the following requirements:

(1) average roundness as measured by use of a flow particle image analyzer is 0.70 to 0.99; and

(2) average particle size as measured by means of laser diffractometry is 1 to 50 μm.

17. The high-density electrode as claimed in any one of claims 14 to 16, wherein the graphite material is carbon particles containing, in an amount of 50 mass% or more, graphite particles satisfying the following requirements:

(1) C_0 of a (002) plane as measured by means of X-ray diffractometry is 0.6900 nm, La (the size of a crystallite as measured along the a-axis) is greater than 100 nm, and Lc (the size of a crystallite as measured along the c-axis) is greater than 100 nm;

(2) BET specific surface area is 0.2 to 5 m^2/g;

(3) true density is 2.20 g/cm^3 or more; and

(4) laser Raman R value (the ratio of the intensity of a peak at 1,360 cm^{-1} in a laser Raman spectrum to that of a peak at 1,580 cm^{-1} in the spectrum) is 0.01 to 0.9.

18. The high-density electrode as claimed in any one of claims 1 to 9, wherein the electrode active substance is a Li alloy.

19. The high-density electrode as claimed in any one of claims 1 to 9, wherein the electrode active substance is a lithium nitride material.

20. The high-density electrode as claimed in any one of claims 1 to 9, wherein the electrode active substance is a silicon oxide material.

21. The high-density electrode as claimed in any one of claims 1 to 9, wherein the electrode active substance is a metal oxide material.

22. The high-density electrode as claimed in claim 21, wherein the metal oxide material contains a tin oxide material in an amount of 60 mass% or more.

23. The high-density electrode as claimed in claim 21, wherein the metal oxide material contains a cobalt oxide in an amount of 60 mass% or more, and the bulk density of the electrode is 3.6 g/cm^3 or more.

24. The high-density electrode as claimed in claim 21, wherein the metal oxide material contains a manganese oxide in an amount of 60 mass% or more, and the bulk density of the electrode is 3.0 g/cm^3 or more.

25. The high-density electrode as claimed in claim 21,

wherein the metal oxide material contains a mixture of a cobalt oxide and a manganese oxide in an amount of 80 mass% or more, and the bulk density of the electrode is 3.4 g/cm^3 or more.

26. The high-density electrode as claimed in claim 21, wherein the metal oxide material contains a nickel oxide in an amount of 60 mass% or more, and the bulk density of the electrode is 3.4 g/cm^3 or more.

27. The high-density electrode as claimed in claim 21, wherein the metal oxide material contains a vanadium oxide in an amount of 60 mass% or more, and the bulk density of the electrode is 2.3 g/cm^3 or more.

28. The high-density electrode as claimed in any one of claims 1 to 9, wherein the electrode active substance is a metal sulfide material.

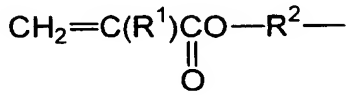
29. The high-density electrode as claimed in any one of claims 1 to 9, wherein the electrode active substance is an iron olivine compound.

30. The high-density electrode as claimed in any one of claims 1 to 29, containing a carbon fiber having a filament diameter of 1 to 1,000 nm in an amount of 0.2 to 20 mass%, and having a capacity density of 100 mAh/g or higher.

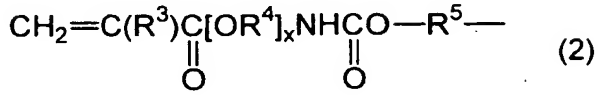
31. The high-density electrode as claimed in claim 30, wherein the electrode absorbs 3 μl of propylene carbonate within 500 seconds at 25°C and 1 atm.

32. The high-density electrode as claimed in any one of

claims 1 to 31, wherein the solid polymer electrolyte comprises at least one compound having as a constituent a unit represented by formula (1) and/or (2):



(1)



(2)

wherein R^1 and R^3 each represents a hydrogen atom or an alkyl group; R^2 and R^5 each represents a divalent group containing oxyalkylene group, fluorocarbon group and/or carbonate group; R^4 represents a divalent group having 10 or less carbon atoms; R^2, R^4 and R^5 may each include a hetero atom, and may have a linear, branched or cyclic structure; x represents 0 or an integer of 1 to 10; and in a case where two or more of polymerizable functional groups represented by the above formulae are contained in one molecule, R^1 to R^5 and x in one functional group may be the same with or different from those symbols in the other functional groups.

33. The high-density electrode as claimed in any one of claims 1 to 32, wherein a non-aqueous solvent employed for the solid polymer electrolyte contains at least one species selected from the group consisting of ethylene carbonate, diethyl carbonate, dimethyl carbonate, methyl ethyl carbonate, propylene carbonate, butylene carbonate, and vinylene carbonate.

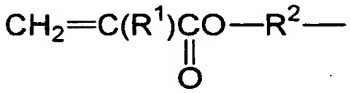
34. A battery comprising a high-density electrode as recited in any one of claims 1 to 33.

35. A secondary battery comprising a high-density electrode as recited in any one of claims 1 to 33.

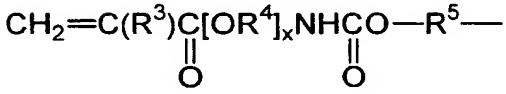
36. A lithium battery electrode, obtained by impregnating a high-density electrode which contains a carbon fiber having a filament diameter of 1 to 1,000 nm in an amount of 0.2 to 20 mass% and has a capacity density of 100 mAh/g or higher, with a solid polymer electrolyte.

37. The lithium battery electrode as claimed in claim 36, wherein the electrode absorbs 3 μl of propylene carbonate within 500 seconds at 25°C and 1 atm.

38. The lithium battery electrode as claimed in claim 36 or 37, wherein the solid polymer electrolyte comprises at least one compound having as a constituent a unit represented by formula (1) and/or (2):



(1)



(2)

wherein R^1 and R^3 each represents a hydrogen atom or an alkyl group; R^2 and R^5 each represents a divalent group containing oxyalkylene group, fluorocarbon group and/or carbonate group; R^4 represents a divalent group having 10 or less carbon atoms; R^2, R^4 and R^5 may each include a hetero atom, and may have a linear, branched or cyclic structure; x represents 0 or an integer of 1 to 10; and in a case where two or more of polymerizable functional groups represented by the above formulae are contained in one molecule, R^1 to R^5 and x in one functional group may be the same with or different from those symbols in the other functional groups.

39. The lithium battery electrode as claimed in any one of claims 36 to 38, wherein a non-aqueous solvent employed for the solid polymer electrolyte contains at least one species selected from the group consisting of ethylene carbonate, diethyl carbonate, dimethyl carbonate, methyl ethyl carbonate, propylene carbonate, butylene carbonate, and vinylene carbonate.